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ABSTRACT

In the Netherlands, a mathematical curriculum change has occurred in the secondary (grammar) school. The new curriculum consists of two programs, Math A and Math B. Students can choose one or both of these programs. Math A prepares for university studies in humanities and economics, while Math B prepares for studies in science, technics, agriculture, and medicine. The first results of the effects of the new curriculum, now used in 52 grammar schools, are reported in this paper. It was found that girls choose more mathematics than before. A similar but less evident effect was found for boys. Girls also choose more Math A, while boys choose more Math B, or both courses. Students, especially girls, who follow Math A perceived the subject less as a male domain than those who follow the traditional program. There is no effect of Math A on perceived relevance and perceived own abilities. It is concluded that the new curriculum has a positive effect on the choice of mathematics by girls, but girls appear to choose Math A to exclude themselves from many university studies. Results of Math A on attitudes toward mathematics should be interpreted with care. Several tables are included. (MNS)

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# Girls and mathematics: the new math program

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ABSTRACT

In the Netherlands the subject of mathematics is a very hot topic today. In general secondary education at the highest level (grammar school) there has been a mathematical curriculum change. One of the objects of math A is to make the subject more attractive and 'life-like', supposing that more pupils and especially girls will choose mathematics and acquire a more positive attitude towards this subject.

The new curriculum consists of two programs, math A and math B. Pupils can choose one of these programs, but can also choose both. Math A only prepares for university studies in humanities and economics, math B for studies in science, technics, agriculture and medicine.

52 Grammar schools already use the experimental curriculum. In the paper the first results of the effects of the new curriculum on choice of mathematics and on attitudes towards this subject will be given.

A significant effect of the new curriculum on choice of mathematics: was found: girls choose more mathematics then before. The same is the case for boys, but this effect is less evident. But girls also choose more math A, while boys choose more math B, or math A as well as math B.

Concerning the effects of math A on the attitudes towards mathematics it was found that pupils who follow math A perceive the subject less as a male domain than pupils who follow the traditional program.

There is no effect of math A on perceived relevance and perceived own abilities (interest, difficulty and selfconfidence).

Girls perceive mathematics to be a male domain less than boys. Boys perceive their own abilities on mathematics as being higher than girls. No difference in perceived usefulness appear between boys and girls. All three findings in regard to difference between boys' and girls' attitudes concern pupils who follow math A as well as those who follow math I.

One can conclude that the new curriculum has a positive effect on the choice of mathematics by girls, but it also appears that girls mostly choose math A so that they exclude themselves from a lot of university studies.

Concerning the effects of math A on attitudes towards math the results have to be interpreted with care.

## INTRODUCTION

In the Netherlands girls and boys formally have equal educational opportunities: compulsory education is of the same duration for girls as for boys, and they have admission to all subjects and facilities. But in fact girls take less advantage of these opportunities than boys: in general secondary education the subjects chosen by boys and girls show a sex-typed pattern; girls more frequently choose languages and humanities; boys more frequently choose sciences. In vocational education boys tend to follow technical education, girls domestic and administrative education. At university girls more frequently study languages and humanities, boys more frequently study sciences, technics and economics. It turns out that on the labour market knowledge of science and technical training offer the best chances for a job and a succesful career.

Sex-typed educational and professional careers are partially developed under influence of the existing distribution of professions between men and woman in our society. Besides this, there are also factors within education and the educational structure that influence the unequal participation of girls and boys in subjects and studies. Education does not strive after sex differences consciously, but - consciously or not - takes them for granted.
Formally pupils and students can make free choices. But in making choices they will anticipate on their future position in society. Since girls generally don't have in mind a future directed solely towards a job and a career, they will choose their subjects and studies on the basis of interest instead of on basis of professional opportunities more often than boys do (Russell, 1979; Compaan en de Kat, 1982). In practice, this means that already in general education girls choose subjects that have a clear 'in daily life applicable' character, like languages, geography, history or biology (Veeken e.a., 1982). With these subjects chosen in general education their further educational and professional career is limited. This is especially the case with the subject of mathematics. Nearly all university studies after general secondary education - except languages - require mathematics for admission. So do all technical and economical

vocational studies. We must conclude that one of the main reasons why girls in fact have less opportunities for a succesful career than boys, is due to the fact that girls don't take mathematics in general secondary education and this is partially due to the great freedom of choices that exists in the educational structure.
This is one of the reasons why there are plans to make mathematics compulsory for all pupils in secondary education just like Dutch language and English already are. Another reason is that mathematical skills are considered as important for everyone. However, promoting compulsory mathematics is only useful if at the same time actions are taken to make the subject more attractive and 'life-like' for pupils and especially for girls. This is why there are a lot of new developments in mathematics today. One of these developments is the change of the mathematics curriculum in general secondary education at the highest level (grammar school).

The New Mathematics Program

In grammar schools pupils have to choose their subjects in grade 4 (see Appendix I for a diagram and description of the Dutch school system). Two mathematics programs can be chosen: math I and math II. Math I can be chosen without math II, but math II not without math I. Math I was designed for pupils who have positive attitudes towards mathematics and who are expected to study sciences, technics, agriculture or medicine at university. Math II was designed for pupils who want a more broad foundation of mathematics. This is a very small group of pupils, who will also follow a science study at university. The design of the existing mathematics curriculum offers two important problems.
The first problem concerns the mathematical education of pupils who are interested in humanities or economics at university. These studies consider mathematical knowledge and aptitude as necessary for some of their subjects. But most of their students haven't had mathematics at grammar school. So universities had two choice opportunities: either require math I or take special actions for students without math. What happened was that math I became a critical filter for admission to almost all university studies.

Pupils who want to study humanities had to choose math I, even if they didn't like it and found it too difficult. These pupils had big problems with math I, which is too theoretical for them and contains many parts that are not relevant for their future. The second problem concerns the mathematical knowledge of pupils who followed science, technics or agriculture at university. These pupils missed special abilities, since training of these abilities was not included in the math I program nor in the math II program.
These dissatisfactions with the existing math curriculum have resulted in a curriculum change.
Math I, which is now called math B, will remain with the addition of geometry, math II will disappear and a new math program - math A - has been developed.
Math B will be compulsory for pupils who want to study sciences, technics or agriculture and will consist of analysis and geometry. Pupils who will choose for humanities or economics have to follow math A or math B. Math A has a strong applicable character and consists of simple analysis and applicable analysis, matrix counting and applications, probability counting and statistics and computer science. Math A is especially designed for preparation to humanities and economics.
Pupils with a lot of interest in mathematics can take both programs. So the most important objective of the new math program is to make a better fit between secondary education and university. A side objective is to make math more attractive for pupils and especially for girls, so that they choose it more often and get better results on this subject. This objective has to be achieved by math A. In August 1981 two grammar schools started with the experimental new math program in grade 5 and 6. In August 1983 10 schools and in August 1984 another forty schools were added to the experiment. Pupils in grade 4 already receive a program which prepares for the new curriculum so that they know what they are choosing for at the end of grade 4.

This paper will give information about the effects of the new math program on pupils' choices of mathematics and about the effects of math A on their attitudes towards the subject. Our special interest is in the effects on choices and attitudes of girls. The study presented here is part of a longer research project in which the other

objectives of the new mathematics program are also studied. This project started in September 1984 and will be finished in November 1986. The project is sponsored by the National Foundation of Educational Research.

## THEORETICAL FRAMEWORK

In the Netherlands very little research has been done on the problem of girls and mathematics although the problem here is as big as in the U.S. So we have to concentrate on American research for explaining the fact that girls don't choose mathematics as frequently as boys.
At the moment it is clear that biological factors can't explain the phenomenon. Social and psychological factors play the most important role. Petersen (1979) concludes that sex-differences in mathematical choices and achievements are the result of biological predisposition which are - partially or completely - realised by psychological features of pupils, developed during socialization. Differences in psychological features between boys and girls explain the extent in which they want to or can exert themselves to achieve well in a subject and also explain the choice of this subject. Such differences in psychological features between boys and girls have been shown repeatedly. Already at a very early age children show sex-stereotypes (Kohlberg, 1966; Kuhn et al. 1978). In grade two of primary school children consider verbal skills as female and spatial and mathematical skills as male (Dwyer, 1974; Nash, 1975). Grown-ups also tend to consider mathematics as a male domain (Tangri, 1982; Parsons, 1984). Sex stereotyping of a subject appear to influence achievement in this subject (Montemayor, 1974; Stein et al. 1971; Fennema and Sherman, 1977). The results of research by Stein and Bailey (1973) show that girls make higher demands on themselves when they are confronted with tasks they consider as appropriate for their own sex than when they are confronted with tasks they consider as appropriate for boys. So girls make less demands on themselves on mathematical tasks and this low achievement motivation influences their achievements. It is evident that girls also will not choose a subject they consider as not appropriate for their sex. Fox (1977) concludes almost the same. She showed that girls have less self-confidence in regard to mathematics.

A strong relationship has been found between self-confidence and mathematics achievement both for girls as for boys. More girls than boys have an extreme lack of self-confidence and these feelings hinder learning of mathematics and contribute to avoiding it as soon as possible. So, at the moment of choosing subjects most girls won't take mathematics. (Fox, 1977; Armstrong, 1979; Sherman, 1979; Tobias and Weisbrod, 1980).

Also the perception of usefulness of mathematics in later life seems to be an important predictor of choice of mathematics by girls (Armstrong, 1979; Sherman, 1979; Stallings, 1980; Kelly, 1978).

Finally girls conceive mathematics as being more difficult than boys do (Kremers, 1981; Parsons, 1984).

About liking of mathematics the research results are not evident. For the Dutch situation Kremers (1981) found that boys like mathematics more than girls, whereas Aiken (1976) did not.

We must conclude that girls have another (more negative) attitude towards mathematics than boys, which causes them to tend to drop mathematics as soon as possible. But girls are not born with these attitudes and these attitudes are not unchangeable. Parsons (1984) concludes that it is possible to influence these attitudes by making mathematics more attractive and 'life-like'.

The New Mathematics Curriculum and especially math A is supposed to do this.

We now can formulate the following hypotheses:

1. In schools where the New Mathematics Curriculum is taught more pupils choose mathematics than in schools where the old curriculum is still taught.
2. In schools where the New Mathematics Curriculum is taught more girls choose mathematics than in schools where the traditional curriculum is still taught.
3. In schools where the New Mathematics Curriculum is taught more girls than boys follow math A and more boys than girls follow math B.
4. Pupils who follow math A program have a more positive attitude towards mathematics than pupils who follow the old math I program.
5. Boys and girls who follow math A do not differ in their attitudes towards mathematics. Boys who follow math I have a more positive attitude towards math than girls who follow math I.

## METHODS

### Subjects

44 of the 52 schools who used the experimental New Mathematics Curriculum co-operated to the research project. A comparative group of 41 schools with the old program was selected and matched with the experimental group on the variables location, size and ratio boys/girls. The pupils in grade 5 of these 85 schools were the research objects. From all of them information was collected about subject choices. A part of them, only the pupils who follow math A or math I, filled in a questionnaire about their attitudes towards mathematics. The exact number of pupils (boys/girls etc.) is reported in the result section.

### Measurement of attitudes towards mathematics.

A written questionnaire was developed to measure pupils' attitudes towards mathematics. At the beginning the questionnaire consisted of five subscales:

. interest in mathematics
. perceived usefulness of mathematics
. perceived difficulty of mathematics
. selfconfidence in mathematics
. mathematics as a male subject.

For the construction of the questionnaire the items and scales of existing instruments were used (e.g. Parsons, 1984; Fennema and Sherman, 1978; Ernest, 1976; Fox, Tobin and Brody, 1979).
The questionnaire consisted of 60 items with four response categories: agree, partly agree, partly disagree and disagree, which got respectively the scores 4, 3, 2 and 1.
To test the questionnaire we performed an item-analysis on the five subscales.
The results are the following:

Table 1: coëfficients of reliability of the 5 subscales

| Subscales | Coëff.Alpha | Mean | Stand.dev. | N-items |
|---|---|---|---|---|
| 1. Interest | .91 | 25.4 | 5.4 | 10 |
| 2. Usefulness | .77 | 27.8 | 3.6 | 15 |
| 3. Difficulty | .95 | 25.3 | 6.0 | 13 |
| 4. Self-confidence | .77 | 32.1 | 4.6 | 13 |
| 5. Male domain | .88 | 34.2 | 4.9 | 9 |

From this table it can be concluded that the subscales are reliable enough. But we also want to know how the subscales are related to each other, in order to know if we can speak of one dimension of attitude towards mathematics. Table 2 shows the results.

Table 2: relationships between the 5 subscales

| Subscales | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. Interest | - | | | | |
| 2. Usefulness | .34 | - | | | |
| 3. Difficulty | .59 | .26 | - | | |
| 4. Self confidence | .56 | .27 | .78 | - | |
| 5. Male domain | .04 | .05 | .03 | .07 | - |

We must conclude that the subscales perceived difficulty, self-confidence and interest correlate relatively highly with each other. The subscales perceived usefulness and math as a male domain show a low respectively negative correlation with the other subscales. For this reason we consider perceived difficulty, selfconfidence and interest as one dimension of attitude towards mathematics, which we call own perceived abilities. The other two subscales remain as separate dimensions of attitude towards mathematics. After removement of 18 items with an item-rest correlation which was too low, the total amount of items in the questionnaire was 42. The eventual reliability coëficients of the three remaining subscales are presented in table 3.

Table 3: coëfficients of reliability of the 3 eventual subscales

| Subscales | Coëff.Alpha | Mean | Stand.dev. | N.-items |
|---|---|---|---|---|
| 1. Perceived own abilities | .95 | 77.5 | 14.6 | 29 |
| 2. Usefulness | .75 | 25.5 | 4.1 | 10 |
| 3. Male domain | .77 | 9.6 | 1.9 | 3 |

RESULTS

In this section the results will be presented with the help of the hypotheses formulated earlier.
First the hypotheses concerning the relationship between the curriculum presented (new or traditional curriculum) and mathematics choices and concerning the effects of sex of pupils on choice of mathematics will be tested. After that the hypotheses concerning the relationship between program followed (math A or math I) and attitudes towards mathematics and the effect of pupils' sex on this relationship will be tested.

Choice of mathematics

The figures of mathematics choices by girls and boys under the new and traditional curriculum are presented in table 4.

Table 4: mathematics choices by girls and boys grade 5; 1985.

| math choice | old curriculum | | new curriculum | | total |
|---|---|---|---|---|---|
| | boys | girls | boys | girls | |
| minimally one math program | 91% | 77% | 86% | 67% | 81% |
| no math program | 9% | 23% | 14% | 33% | 19% |
| total | 100% | 100% | 100% | 100% | 100% |
| | n=2245 | n=2014 | n=2046 | n=1845 | n=8150 |

It appears that pupils who are offered the new curriculum choose a mathematics program significantly more frequently than pupils who are offered the traditional curriculum ($X2 = 64.47$; $df = 1$; $p < .001$). This is also the case for girls only ($X2 = 48.16$; $df = 1$; $p < .001$) as well as for boys only ($X2 = 23.59$; $df = 1$; $p < .001$).

Table 5 gives information about which program boys and girls choose under the new curriculum (math A, B or A and B).

Table 5: math program chosen by boys and girls under the new math curriculum, 1985.

| program followed | boys | girls | total |
|---|---|---|---|
| Math A | 28% | 47% | 37% |
| Math B | 23% | 15% | 20% |
| Math A and B | 39% | 15% | 27% |
| No Math | 10% | 23% | 16% |
| Total | 100% | 100% | 100% |
| | n=2245 | n=2014 | n=4259 |

Girls choose math A significantly more frequently than boys do ($X2 = 160.97$; $df = 1$; $p < .001$). Boys choose more frequently than girls math A as well as math B ($X2 = 408.23$, $df = 1$; $p < .001$).

We must conclude that the hypotheses 1,2 and 3 are supported by the results.

Attitudes toward mathematics

In testing the hypotheses concerning attitudes toward mathematics the three dimensions mentioned earlier, each form a dependent variable. The independent variables are math program followed (math A or math I) and sex of the pupils.
The results of the effect of the math A program on pupils attitudes can be found in table 6.

Table 6: Effect of the math. A program on pupils attitudes towards mathematics, 1985.

| Dependent var. | Group | n | Mean | T-statistic | Df | p |
|---|---|---|---|---|---|---|
| Perceived own abilities | math A | 637 | 2.53 | .15 | 1045.36 | .880 |
| | math I | 514 | 2.52 | | | |
| Usefulness | math A | 701 | 2.51 | -.1.00 | 1195.25 | .319 |
| | math I | 545 | 2.54 | | | |
| Male domain | math A | 734 | 3.26 | 2.42 | 1169.59 | .016 |
| | math I | 557 | 3.17 | | | |

It appears that pupils who follow math A perceive mathematics less as a male domain than pupils who follow math I (N.B. The higher the mean item score on this subscale, the more positive the attitude, thus the less perception of mathematics as a male domain).
This is interesting since the math A program is meant to neutralize the preconceived opinion of pupils that mathematics is a male domain.
But the effect is very small and the other two dimensions of attitude toward mathematics do not differ between pupils who follow math A and math I.
A test to see if the effects could be found for girls, was also carried out.
The results show no significant differences on the three attitude subscales between girls who follow mat A and those who follow math I.
The results concerning the effect of the program followed on differences between boys and girls in attitudes towards mathematics are shown in table 7 and 8.

Table 7: Differences in attitudes between boys and girls who follow the math A program, 1985.

| Dependent var. | Group | n | Mean | T-statistic | Df | p |
|---|---|---|---|---|---|---|
| Perceived own abilities | boys | 252 | 2.57 | 1.99 | 556.21 | .047 |
| | girls | 385 | 2.50 | | | |
| Usefulness | boys | 286 | 2.53 | .75 | 574.98 | .452 |
| | girls | 415 | 2.50 | | | |
| Male domain | boys | 303 | 3.17 | -3.22 | 617.23 | .001 |
| | girls | 431 | 3.32 | | | |

It appears that boys and girls perceive mathematics to be equally useful; girls perceive mathematics to be a male domain less than boys. But they also perceive their own abilities on this subject as less positive than boys ($p < .05$).
Table 8 present the findings for pupils who follow the math I program.

Table 8: Differences in attitudes between boys and girls who follow the math I program, 1985.

| Dependent var. | Group | n | Mean | T-statistic | Df | p |
|---|---|---|---|---|---|---|
| Perceived own abilities | boys | 274 | 2.56 | 1.79 | 506.67 | .075 |
| | girls | 240 | 2.49 | | | |
| Usefulness | boys | 291 | 2.53 | -0.20 | 528.74 | .839 |
| | girls | 254 | 2.54 | | | |
| Male domain | boys | 303 | 3.10 | -3.16 | 541.47 | .002 |
| | girls | 253 | 3.27 | | | |

The results show almost the same picture as that have been given in table 7. The difference in perceived own abilities between boys and girls who follow math. I is a little less significant ($p < .10$) than between boys and girls who follow math A.

## CONCLUSIONS

In the first place we can conclude that the New Mathematics Curriculum indeed leads to a more frequent choice of mathematics. This is more evident for girls than for boys. But under the new curriculum still 23% of the girls don't choose mathematics against only 10% of the boys. Most girls choose math A, while most boys choose math A as well as math B. This means that girls exclude themselves, more than in the traditional situation, from admission to all possible university studies, since math A only gives admission to humanities and economics. Most boys keep all opportunities open since math A and B as well as math B alone gives admission to all university studies. By testing the hypothesis concerning the effects of math A on attitudes toward mathematics it appears that pupils who follow math A consider mathematics as a male domain significantly less than pupils who follow math I. However, the effect is only very small and probably significant because of the great amount of pupils. When we test the same hypothesis for girls only the effect is not significant any more. In regard to the other two dimensions of attitude toward mathematics no differences were found between pupils who follow math A and those who follow math I. Concerning the differences between boys and girls in regard to the three dimensions of attitude towards mathematics it appear that girls consider mathematics as a male domain less than boys. Also in regard to perceived own abilities, a difference between boys and girls was found, favouring boys. No differences in perceived usefulness appear between boys and girls. All three findings in regard to differences between boys' and girls' attitudes concern pupils who follow math A as well as those who follow math I.

From the results one cannot yet conclude that the objective of math A to make mathematics more attractive for pupils and especially for girls has not been realised. Three explanations for the findings are presented here.

1) Among the pupils who follow math A are a lot of pupils who have relatively negative attitudes toward mathematics but have chosen math A because it is new. When confronted with the traditional math I they wouldn't have chosen math. The group of pupils who follow math I is more homogeneous. If this supposition were true, the standard deviation on the different attitude scales would be higher for pupils who follow math A than for those who follow math I. This is not the case.
2. There is a ceiling in attitudes towards mathematics. Pupils who follow math I have already reached this ceiling at the moment of choice. Pupils who follow math A initially are sceptical, but have reached the ceiling after one year of following math A. This supposition will be tested in the next fase of the research project by comparing the attitudes of pupils in grade 4 with the attitudes of pupils in grade 5 (NB the pupils who were in grade 4 last schoolyear also have filled in the attitude questionnaire and for these pupils a repeated measurement will take place next month (May, 1986). Unfortunately it is not possible to do the same for pupils who follow math I, because the new curriculum is now used in all grammar schools (since August 1985).
3. The effects of math A are only visible after a longer periode of following the program. This explanation will be controlled next month by a repeated measurement of attitudes of the pupils in grade 6 who filled in the questionnaire last year when they were in grade 5.

   As yet it must be concluded that the new mathematics curriculum leads to chosing mathematics more frequently, but not to more positive attitudes towards mathematics. In regard to the choice of mathematics the effects of the curriculum are different for boys than for girls, in regard to attitudes towards mathematics there is practically no difference.

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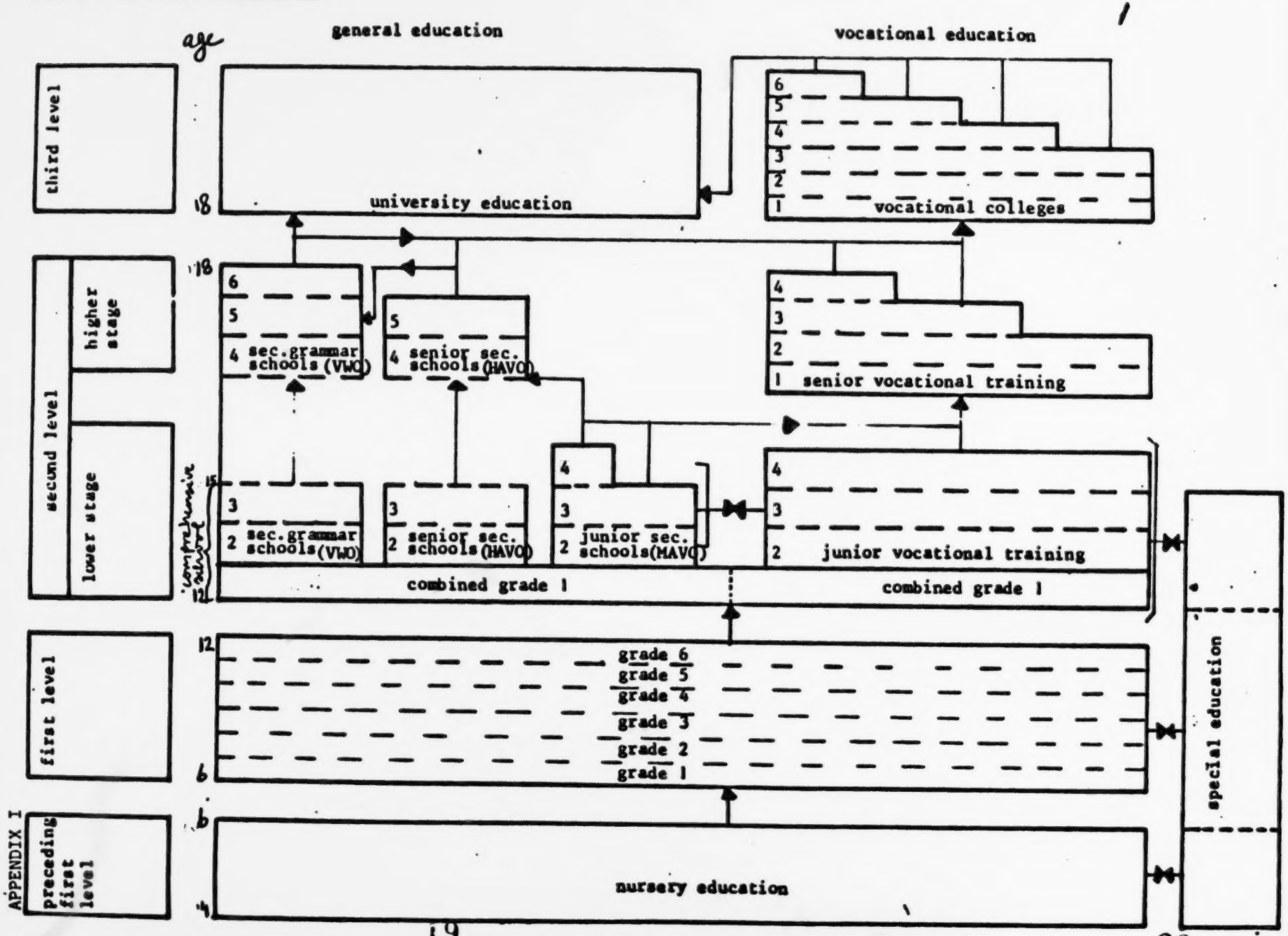
diagram of full-time education.




APPENDIX I

After primary school - generally at the age of twelve - the fundamental choice is between general secondary education and vocational education. Compulsory education continues to the age of sixteen.

In 1962, a Bill which has acquired the nickname of "Mammoth Bill" was passed; when it was implemented, in 1968, it reorganised the secondary school system in the Netherlands. It established three levels of general secondary education which was called, respectively, MAVO (for 12 to 16-year-olds), HAVO (12-17), and VWO (12-18). This law also introduced a uniform curriculum for the first year in all of these schools, the socalled "bridge year", in order to facilitate the relocation of those pupils whose initial choice had turned out to be wrong.

In the lower forms (the first two for MAVO, the first three for HAVO and the first four for VWO) all students take the same 13-15 subjects at their respective levels, but after that, options are introduced: MAVO-3 students take seven subjects, and six in the next year; HAVO-4 students take eight subjects, and seven in their final year; VWO-5 students take eight subjects, and seven in their last year. There are state-supervised examinations at the end of all these types of school; students who pass are awarded a school leaving certificate. A MAVO certificate entitles a pupil to enter HAVO-4 or certain types of vocational schools; a HAVO certificate entitles a student to enter VWO-5 and certain types of vocational colleges; a VWO-certificate gives admission to universities and vocational colleges.